

MARTIN MARIETTA

MARTIN MARIETTA ENERGY SYSTEMS, INC.

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November 23, 1992

Mr. Donald C. Booher, Site Manager
Paducah Site Office
Department of Energy
Post Office Box 1410
Paducah, Kentucky 42002-1410

Dear Mr. Booher:

Results of the Exposure Assessment for Transuranics at Paducah Gaseous
Diffusion Plant (PGDP) April 1, 1991, to May 1, 1992

The purpose of this memorandum is to briefly summarize the results of the assessment of plant exposure potential to transuranics conducted by the Health Physics Department from May 5, 1991, to June 1, 1992. Details of the assessment are attached.

This assessment suggests that the presence of transuranic materials contributes approximately 114 mRem to the annual average dose. Committed Effect Dose Equivalent (CEDE), received at this plant. This dose is about 1/50 (less than 2.3 percent) of that allowed by the Department of Energy on an annual basis. It was also estimated that 99.9 percent of exposures on an annual basis be less than 1033 mRem CEDE or 1/5 (20.6 percent) of that allowed by DOE per year.

Air samples for transuranics average 4/1000 (0.4 percent) of the DOE limit. Air samples for uranium average 0.007 percent of the DOE limit. On a plantwide basis, air samples contain approximately 17 percent transuranics by radioassay.

The plant average for removable surface contamination for process areas known to have transuranics was approximately 2.7 times the limit for removable transuranics listed in Table 2-2 of the DOE Radiological Control Manual. (Normally occupied areas in the plant are maintained at less than the limits in Table 2-2.) Transferable uranium surface contamination averaged 65 percent of Table 2-2 limits in process areas known to have transuranic contamination and below Table 2-2 limits for normally occupied areas. On a plantwide basis, process area removable surface samples contained 12 percent transuranics by radioassay.

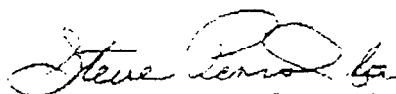
As a result of this assessment, an exposure assessment program has been initiated. Airborne sampling for gross alpha and gross beta contamination continues and individual air sampling results greater than 10 percent derived air concentration

November 23, 1992

continue to be analyzed for transuranics. Routine analysis for transuranics in removable surface samples is no longer considered necessary and has been discontinued, but action levels in transuranic modified materials buildings remain at 20 dpm per 100 square centimeters, the current limit for transuranics.

Detailed information supporting our analysis is attached. If you have any questions about the analysis or the conclusions developed, please call Ty Miller at Bell Extension 6010 or Grville Cypret at Bell Extension 6173.

Sincerely,



Steve Polston, Plant Manager
Paducah Gaseous Diffusion Plant

SP:HTM:rec

Attachments

1. Final Transuranic Exposure Assessment for PGDP
2. Transuranic Exposure Assessment
3. Average TRU and U Activity in Air
4. Statistical Maximum TRU and U Activity in Air
5. Measured Maximum TRU and U Activity in Air
6. Percent TRU (By Alpha Activity) Measured in Air Samples
7. Average Transferable TRU and U Surface Contamination
8. Average and Statistically Maximum TRU in Surface Contamination
9. Average and Statistically Maximum TRU and U in Surface Contamination
10. Transuranic Monitoring Program
11. Exposure to Transuranics by Inhalation
12. Exposure to Transuranics by Ingestion

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Final Transuranic Exposure Assessment for PGDP
November 20, 1992

This is a brief summary of the results of the assessment of plant exposure potential conducted by the Health Physics Department from May 5, 1991, to June 1, 1992. This assessment suggests that the presence of transuranic (TRU) materials contributes approximately 114 mRem to the annual average dose, committed effective dose equivalent (CEDE), received at this plant. This dose is less than 2.3 percent of that permitted by DOE on an annual basis.

During the period of this investigation, approximately 140 air samples and 10 surface samples were collected per week to determine the extent of TRU materials in the plant. From the total samples collected, 650 air and 303 surface samples were analyzed for TRU materials. These samples represent the high 20 of the weekly air samples and all smears above 20 dpm per 100 square centimeters as determined by gross alpha assay. This collection criteria biases our estimates on the high side by an unknown amount.

All isotopic analyses for TRU were done at the Oak Ridge National Laboratory and were reported as gross alpha, uranium alpha, and TRU. In this case, TRU represents the isotopes 241 Americium (Am), 237 Neptunium (Np), 238/239 Plutonium (Pu), and 230 Thorium (Th). An isotopic analysis of TRU at PGDP, 6 samples, suggest 3 percent 241 Am, 6 percent 237 Np, 12 percent Pu, and 79 percent 230 Th. Additional isotopic samples were not collected because, for purposes of safety analysis, the annual limit of intakes (ALI) of each individual isotope was similar and the use of the lowest limit of intake yielded a more conservative (safer) result than using that for a mixture.

Air samples were collected at normally occupied locations thought to be subject to airborne TRU contamination. Most of the locations tested represented locations routinely occupied or potentially routinely occupied by employees. Surface samples were collected at locations known or suspected to have TRU materials present. In general, these surface sampling locations are not accessible to plant personnel in the normal conduct of their duties. This collection criteria tends to increase the high bias in the exposure estimate also. Attachment 2 shows the distribution of samples analyzed by building. More samples were processed from Building C-400 than from any other building. The seeming bias is explained by recognizing that only the most active of the air and surface samples were analyzed for TRU.

The plant average for the 650 air samples was measured as:

- a. Transuranics: $7.65\text{E-}15 \pm 1.1\text{E-}14$ uCi/cc
- b. Uranium: $4.4\text{E-}14 \pm 1\text{E-}13$ uCi/cc
- c. Percent Transuranic: 17 \pm 12 percent

Attachments 3-6 show detailed results for each building surveyed.

The plant average for the 303 transferable surface contamination samples was measured to be:

- a. Transuranics: 54 \pm 158 dpm per 100 square centimeters
- b. Uranium: 649 \pm 2033 dpm per 100 square centimeters
- c. Percent Transuranic: 12 \pm 11 Percent

Attachments 7-9 show detailed sampling results for transferable surface contamination.

Maximum readings for TRU were $3.3\text{E-}13$ uCi/cc for an air sample collected in Building C-400. The maximum uranium air sample was $1.2\text{E-}12$ uCi/cc collected in Building C-333.

The maximum transferable TRU contamination measured in a smear sample was 1980 dpm per 100 square centimeters for a surface sample collected in Building C-360. The maximum uranium surface sample was 29,400 dpm per 100 square centimeters for a wipe sample collected from behind a panel in Building C-360.

The maximum percent TRU in an air sample, collected in Building C-315, was 80 percent, 74.4 percent for a wipe sample collected in Building C-720.

The average annual CEDE due to breathing workplace air (inhalation dose) is estimated to be approximately 23 mRem CEDE, and the maximum probable dose being 126 mRem CEDE. This assumes all of the transuranic component is ^{237}Np , which has the lowest inhalation ALI, using standard assumptions concerning inhalation, level of exertion, hours worked, and retention in the lung. The details of this calculation are shown in Attachment 10.

The average annual CEDE due having contamination adhere to the hands and lips and subsequent swallowing of the material (ingestion dose) is approximately 91 mRem CEDE, the maximum being 907 mRem CEDE. This assumes all of the TRU component

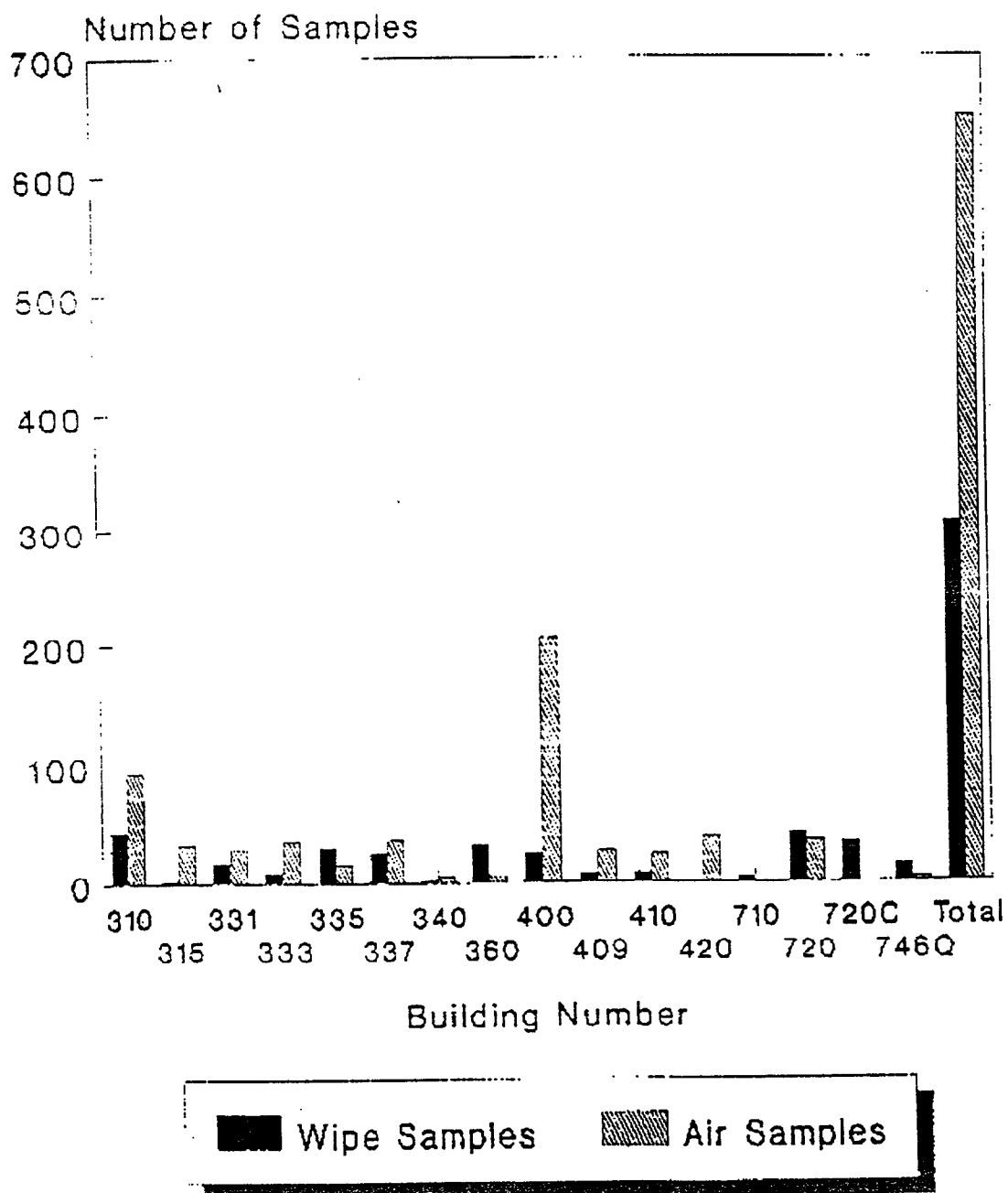
is ^{237}Np and that a person ingests the removable contamination from a 100 square centimeter area per each day at work. The details of this calculation are shown in Attachment 11.

The average total dose (CEDE) for the program is the sum of the inhalation dose and the ingestion dose and is equal to 114 mRem CEDE, the maximum being 1033 mRem CEDE. This assumes all of the TRU is ^{237}Np and other assumptions as above. This maximum dose estimate is consistent with the estimates made in IT Corporation/Nuclear Sciences Report Number IT/NS-91-109, September 2, 1992, Personnel Exposure Potential to Transuranic Materials at the Paducah Gaseous Diffusion Plant, by Carol Berger et. al., using fecal analysis results.

As a result of this analysis, our air sampling program has been revised. Both air and surface sampling for gross alpha and gross beta contamination and individual air sampling results greater than 10 percent derived air concentration continue to be analyzed for TRU. Routine analysis for TRU in transferable surface samples is no longer considered necessary and has been discontinued; however, action levels in Transuranic Modified Materials Buildings remain at 20 dpm per 100 square centimeters, the current limit for TRU. Selected samples exceeding the 20 dpm limit will be analyzed for TRU.

ATTACHMENT 2

Transuranic Exposure Assessment Number Air and Wipe Samples Analyzed



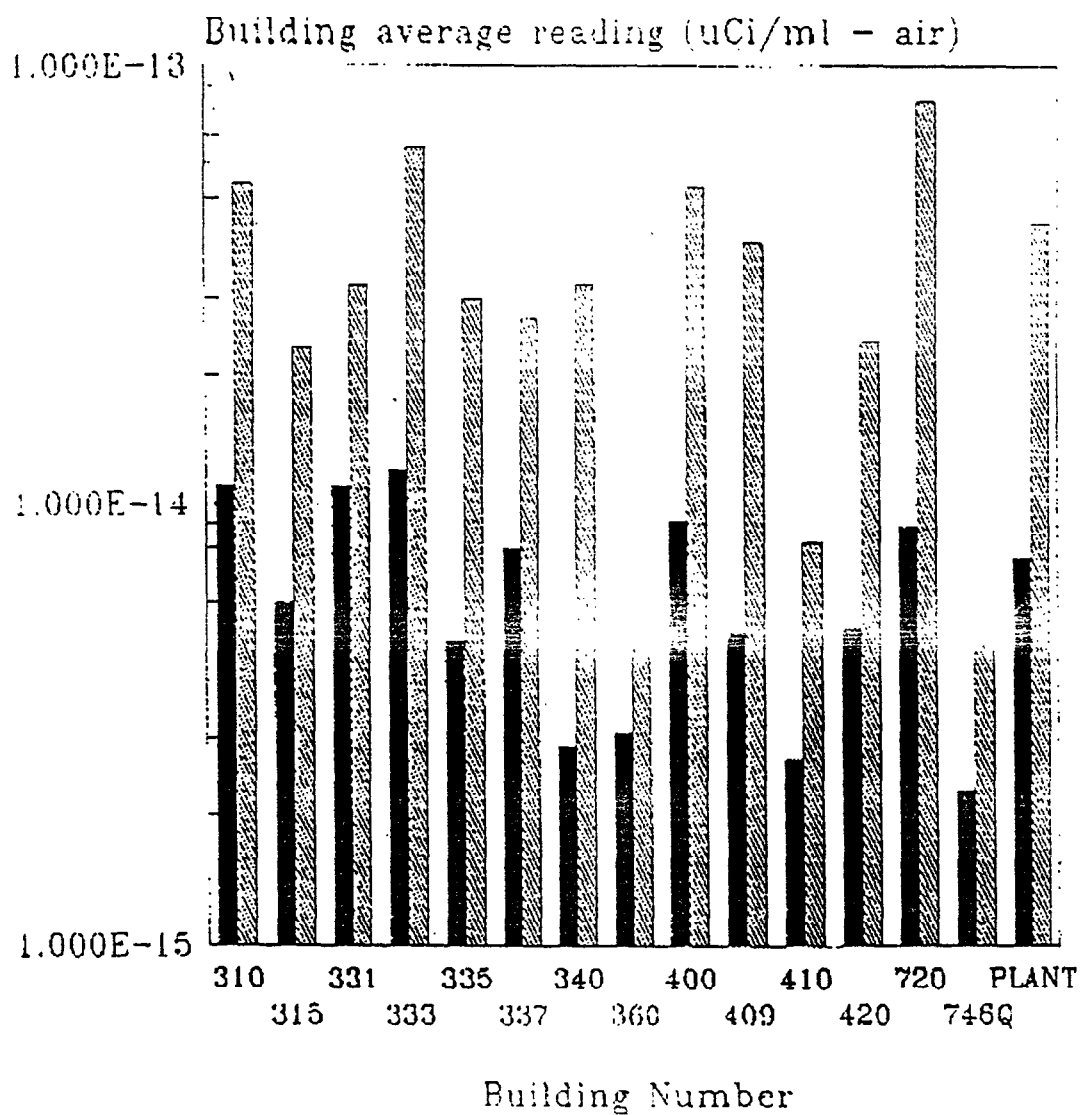
Data Collected From 5/1/91 to 5/1/92

ATTACHMENT 3

AVERAGE TRU AND U ACTIVITY IN AIR

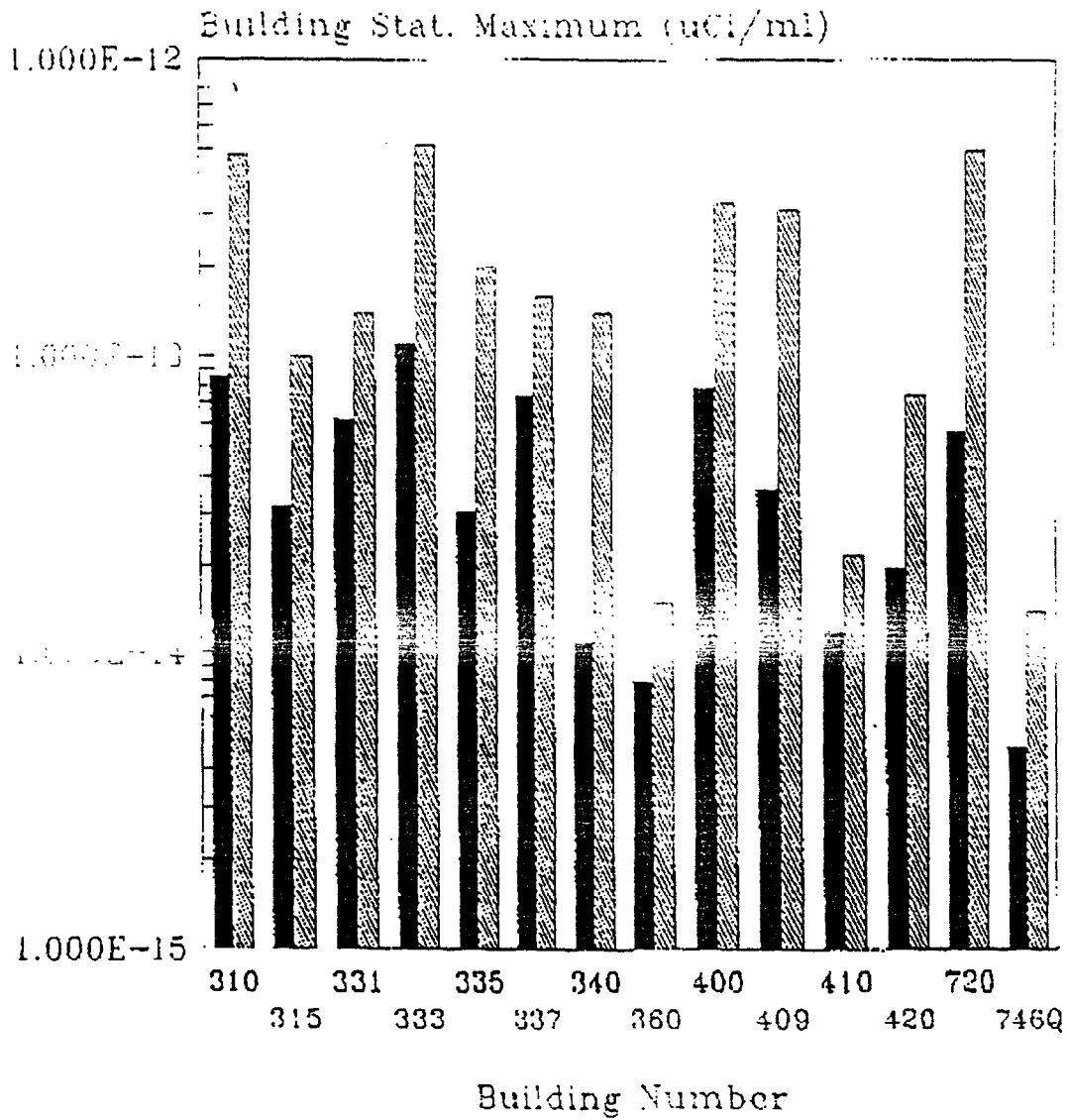
Average, all Tru samples $7.7\text{E-}15$ uCi/cc

Average, all U sample, $4.4\text{E-}14$ uCi/cc



ATTACHMENT 4

STATISTICALLY MAXIMUM* TRU AND U ACTIVITY IN AIR

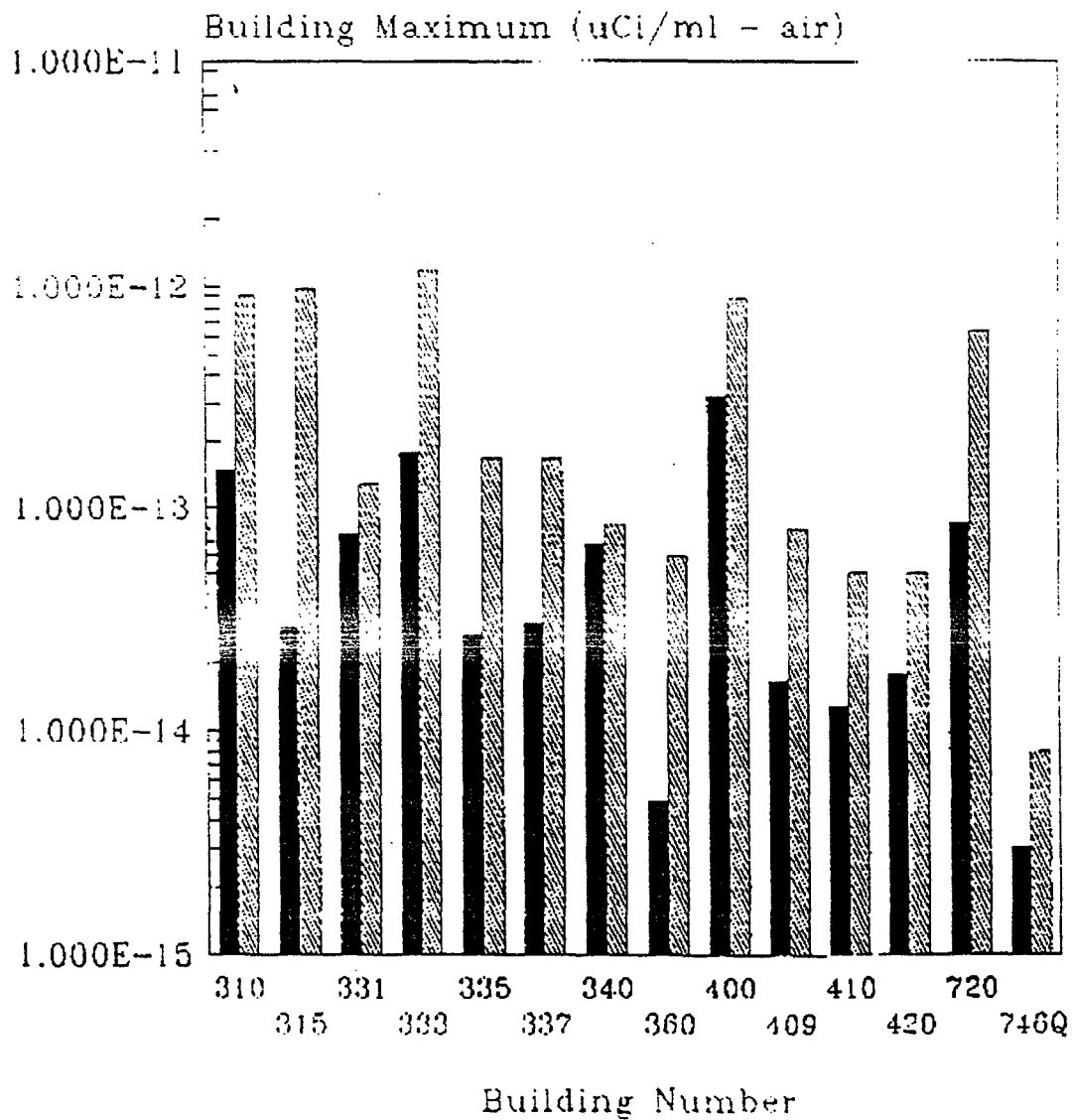


TRU Conc.
 Uranium Conc.

* Average plus three standard deviations

ATTACHMENT 5

MEASURED MAXIMUM TRU AND U ACTIVITY IN AIR



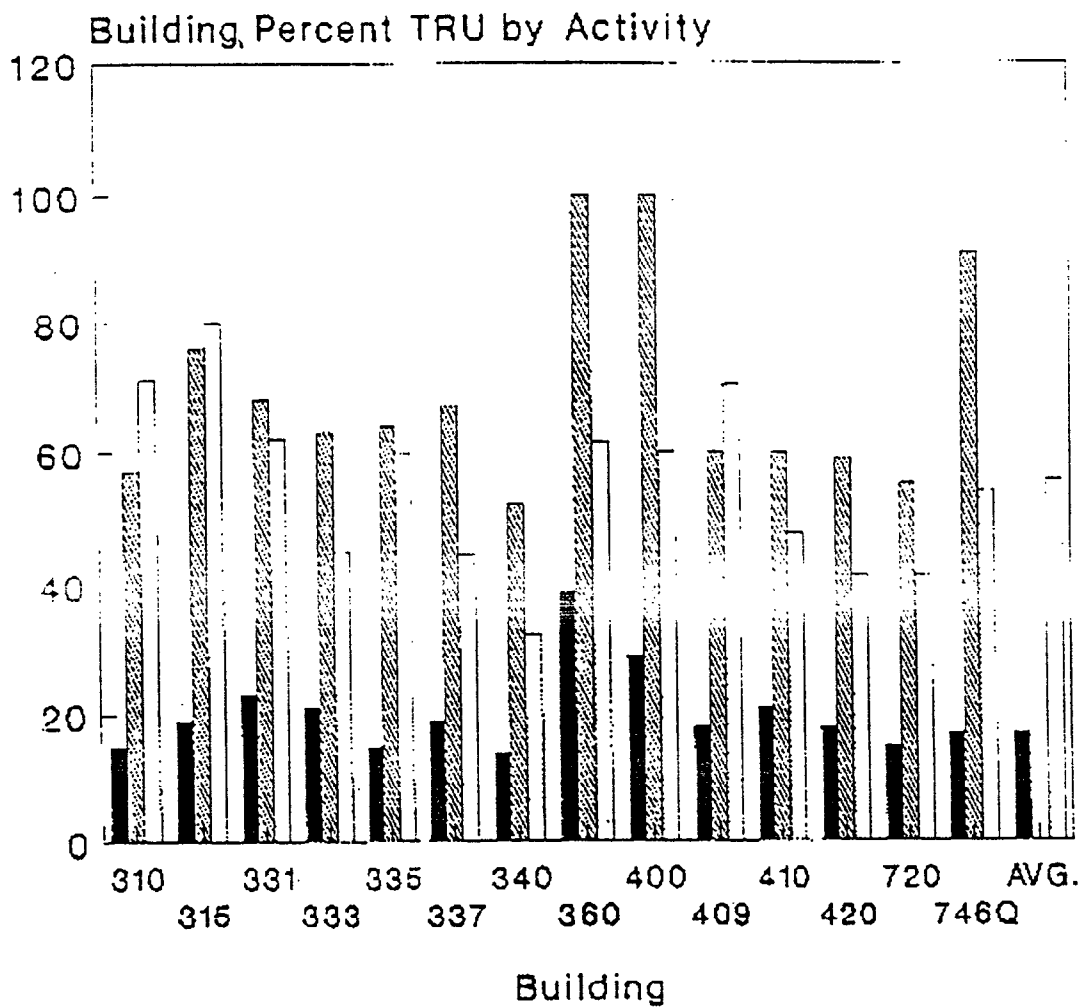
TRU Conc.



Uranium Conc.

ATTACHMENT 6

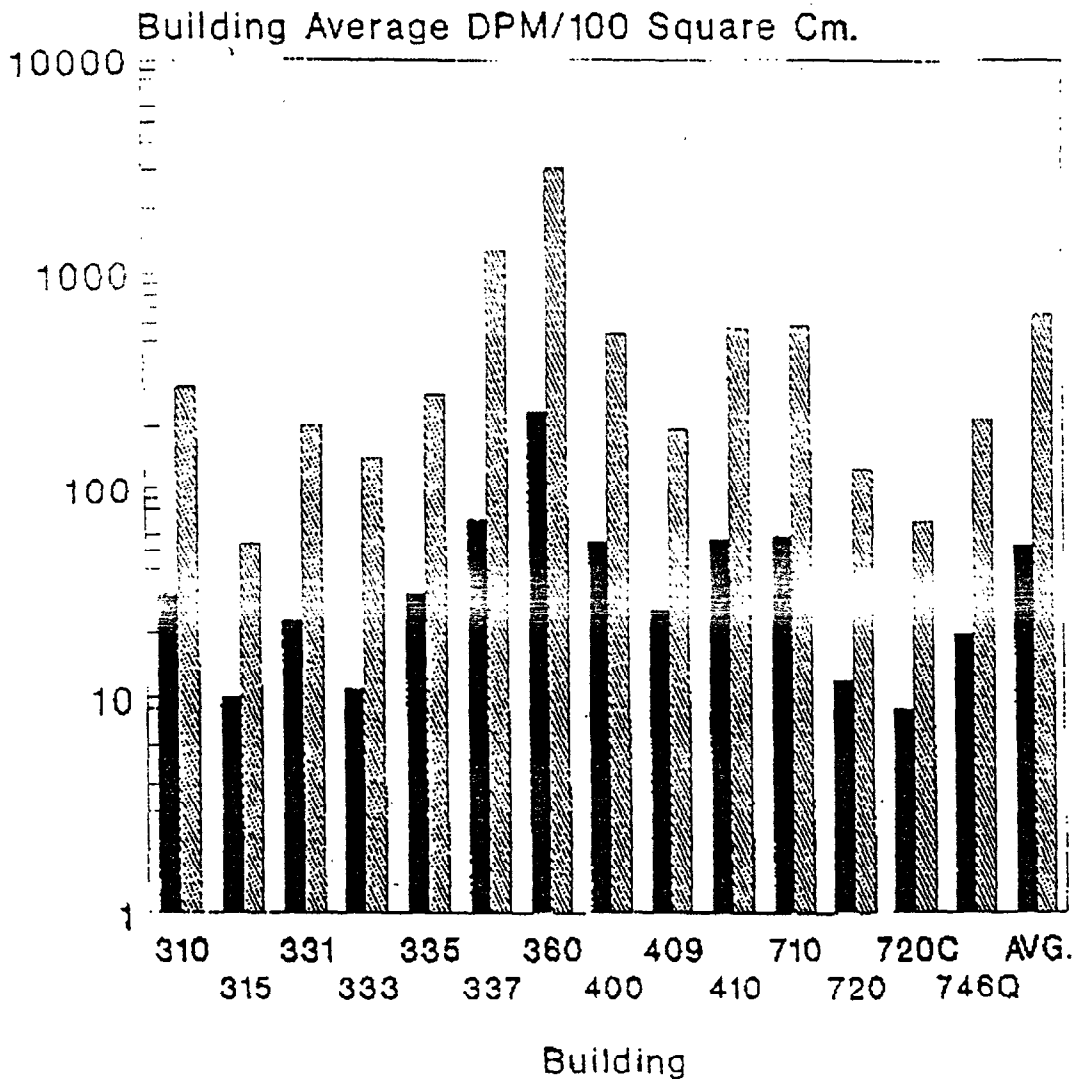
PERCENT TRU (BY ALPHA ACTIVITY)
MEASURED IN AIR SAMPLES
AVERAGE TRU 17+/-11 %



AVERAGE
 STATISTICAL MAXIMUM
 MEASURED MAXIMUM

MEASURED MAX 55.7%

AVERAGE TRANSFERABLE TRU AND U SURFACE CONTAMINATION AVERAGE TRU, 54 +/-158 DPM/100 CM2



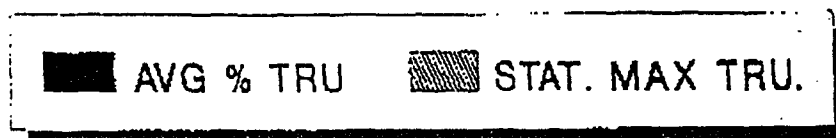
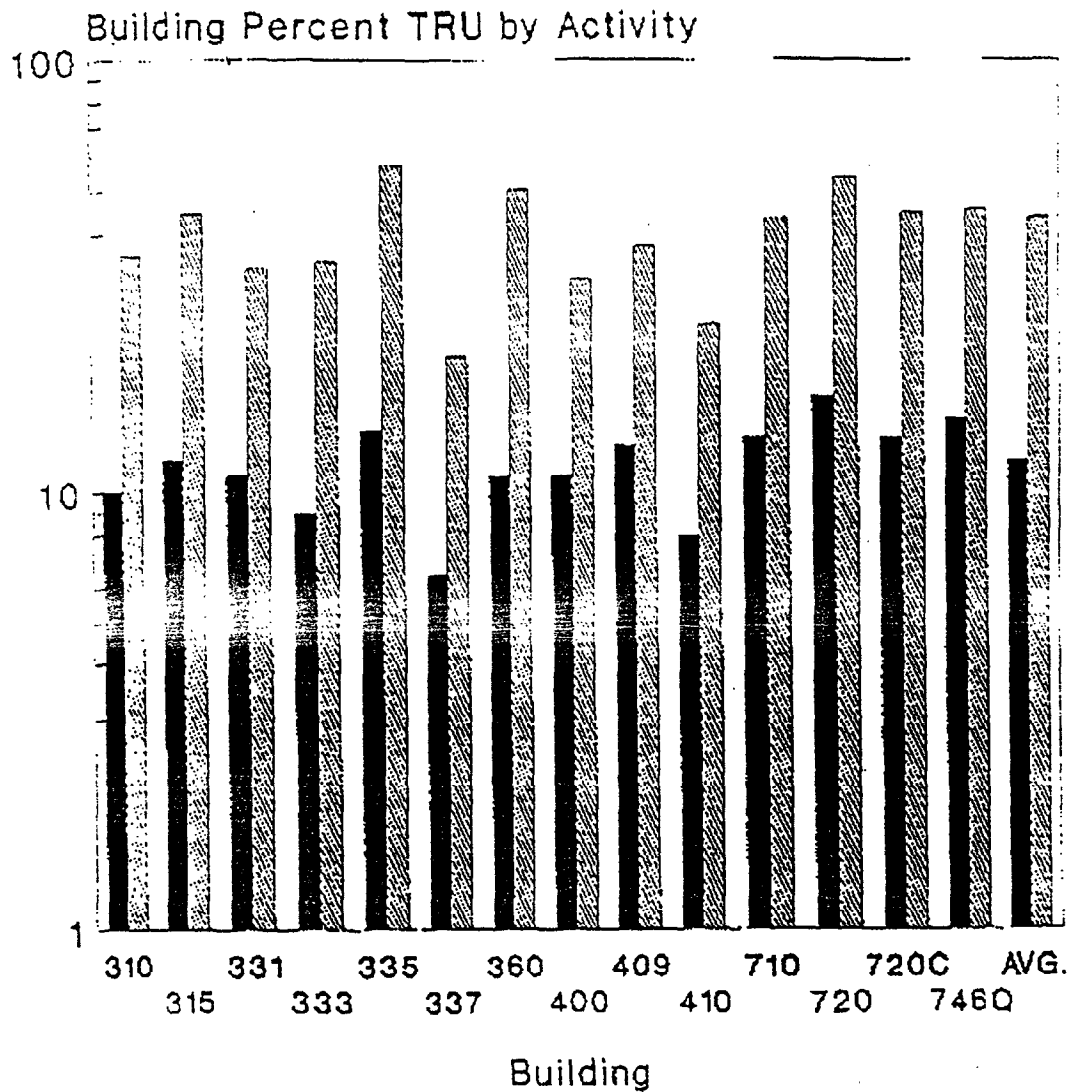
■ TRANS. TRU ▨ TRANS. U

AVERAGE U, 840 +/- 2033 DPM/100 CM2

ATTACHMENT 8

AVERAGE AND STATISTICALLY MAXIMUM* PERCENT TRU IN SURFACE CONTAMINATION

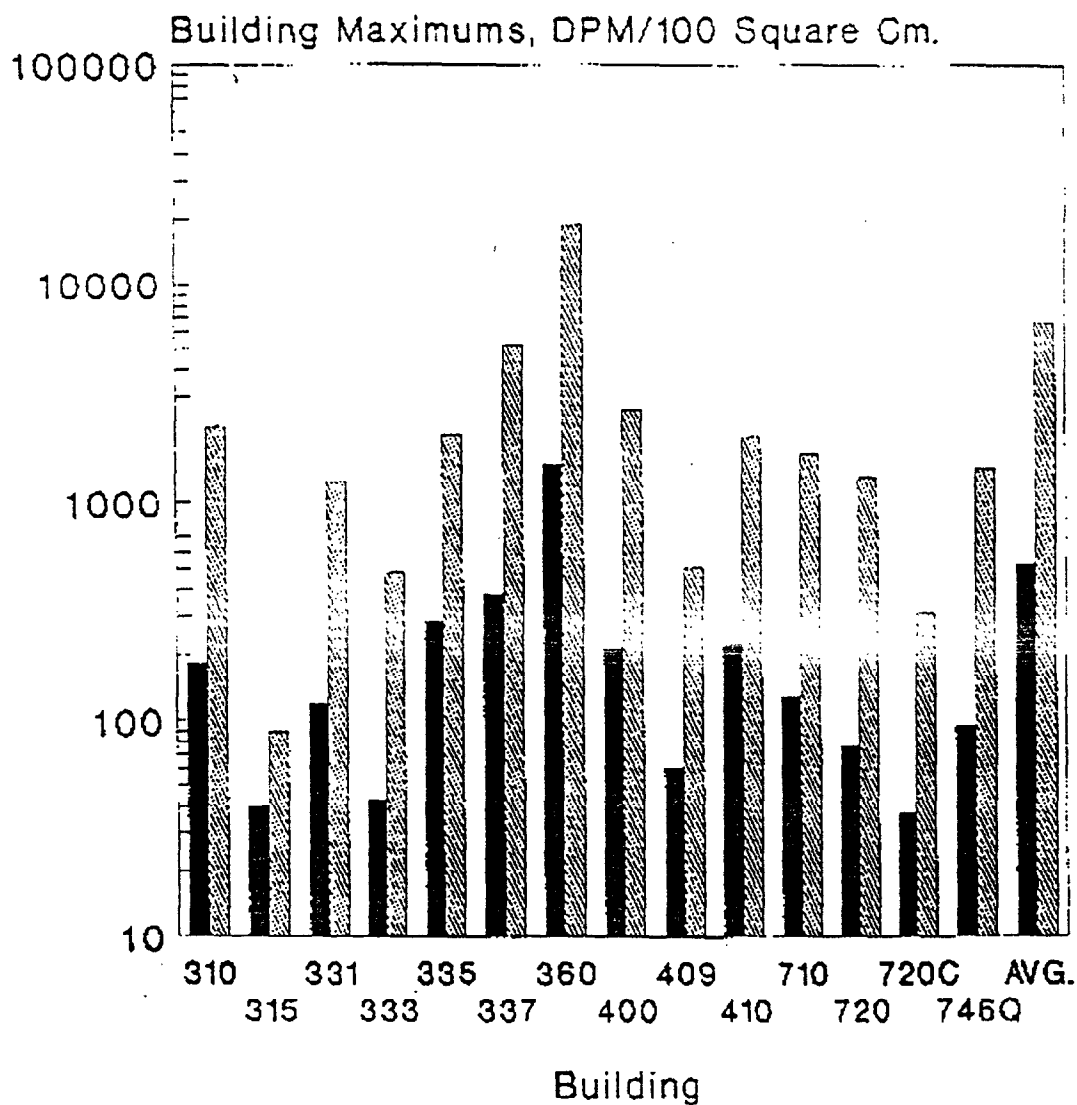
*Average plus three standard deviations



AVERAGE PERCENT TRU 12-7-77 11%

AVERAGE AND STATISTICALLY MAXIMUM* TRU AND U IN SURFACE CONTAMINATION

* Average plus Three Standard Deviations



STAT. MAX. TRU



STAT. MAX. U.

ATTACHMENT 10

Transuranic Monitoring Program First Year Data Summary

Table One: Transuranic Transferable Contamination Data

Building	Transuranics		Uranium	
	Avg. Smear (dpm/100 cm ²)	Avg. + 3*s (dpm/100 cm ²)	Avg. Smear (dpm/100 cm ²)	Avg. + 3*s (dpm/100 cm ²)
310	31	182	308	2154
315	10	40	54	90
331	23	119	203	1251
333	11	43	142	482
335	31	285	283	1991
337	71	384	1263	5293
360	234	1483	3006	19054
400	56	218	534	2651
409	26	61	192	506
410	57	226	565	1951
710	50	129	586	1614
720	12	77	126	1291
720C	9	37	70	309
746Q	20	95	218	1416
Plant Wide	54	530	649	6749

Table Two: Air Sampling Data

Building	Transuranics		Uranium	
	Average (uCi/cc)	Avg + 3*s (uCi/cc)	Average (uCi/cc)	Avg. + 3*s (uCi/cc)
310	1E-14	8.6E-14	5.4E-14	4.8E-13
315	6E-15	3.2E-14	2.3E-14	1E-13
331	1.1E-14	6.2E-14	3.2E-14	1.4E-13
333	1.2E-14	1.1E-13	6.6E-14	5.2E-13
335	5E-15	3.1E-14	3E-14	2E-13
337	8E-15	7.4E-14	2.7E-14	1.6E-13
340	2.9E-15	1.1E-14	3.2E-14	1.4E-13
360	3.1E-15	8E-15	5.2E-15	1.5E-14
400	9.2E-15	7.9E-14	5.3E-14	3.3E-13
409	5.2E-15	3.7E-14	4E-14	3.1E-13
410	2.7E-15	1.2E-14	8.2E-15	2.2E-14
420	5.3E-15	2E-14	2.4E-14	7.5E-14
710	***	***	***	***
720	8.2E-15	5.7E-14	8.3E-14	5E-13
720C	***	***	***	***
746Q	2.3E-15	4.8E-15	5.4E-15	1.4E-14
Plant Avg.	7.6E-15	***	4.4E-14	***

*** Not Available or Not Measured

Table Three: Percentages of TRU in Air and Transferable Contamination Samples

	Surface Samples		Air Samples	
Building	Avg. Percent TRU	Stat. Max TRU	Avg. Percent TRU	Stat. Max TRU
310	10	36	15	57
315	12	45	19	76
331	11	34	23	68
333	9	35	21	63
335	14	58	15	64
337	6.5	21	19	67
340	***	***	14	52
360	11	51	39	100
400	11	32	29	100
409	13	38	18	60
410	8	25	21	60
420	***	***	18	59
710	13.5	44	***	***
720	17	54	15	55
720C	13.5	45	***	***
7460	15	46	35	91
Plant Wide	12	44	17	***

*** Not Measured or Not Calculated

Table Four: Actual Measurement Maximums, Air Samples Only

Building	Max TRU Air ($\mu\text{Ci/cc}$)	Max U Air ($\mu\text{Ci/cc}$)	Max Tru Percent
310	$1.5\text{E-}13$	$9\text{E-}13$	71
315	$2.9\text{E-}14$	$9.8\text{E-}14$	80
331	$7.6\text{E-}14$	$1.3\text{E-}13$	62
333	$1.8\text{E-}13$	$1.2\text{E-}12$	45
335	$2.7\text{E-}14$	$1.7\text{E-}13$	60
337	$3\text{E-}14$	$1.7\text{E-}13$	44.5
340	$6.8\text{E-}15$	$8.5\text{E-}14$	32.4
360	$4.9\text{E-}15$	$6\text{E-}14$	61.5
400	$3.3\text{E-}13$	$8.9\text{E-}13$	60
409	$1.6\text{E-}14$	$8\text{E-}14$	70.3
410	$1.3\text{E-}14$	$5.1\text{E-}14$	47.6
420	$1.8\text{E-}14$	$5.1\text{E-}14$	41.4
720	$8.6\text{E-}14$	$6.5\text{E-}13$	41.4
746Q	$3.1\text{E-}15$	$8.1\text{E-}15$	54
Plant Averages of Maximums	$6.9\text{E-}14$	$3.22\text{E-}13$	55.7

EXPOSURE TO TRANSURANICS BY INHALATION

The basic formula for the computation of the inhalation dose resulting from exposure to transuranics and uranium at PGDP is shown below.

Inhalation Dose = [Air Concentration (TRU-uCi/cc) X Hours Exposed (Hrs) X Ventilation Rate (m3/hr) X Lung Retention Factor X 1E6cc per m3/ ALI-TRU (uCi) + Air Concentration-U X Hours Exposed X Ventilation Rate X Retention Factor X 1E6cc per m3/ALI-U) X 5000

Transuranics at PGDP are class W and the Uranium is Class D. The inhalation ALI for the material is shown below.

Radioisotopes	Annual Limit Of Intake
235 U	1.000 uCi
238 U	1.000 uCi
237 Np	0.004 uCi
241 Am	0.006 uCi
238/239 Pu	0.006-0.007 uCi
230 Th	0.006 uCi

Assumptions made in completing the calculation are as follows:

1. The hypothetically exposed plant worker is exposed 2000 hours per year.
2. The level of exertion is classed as light work, 1.2 m3 of air breathed per hour.
3. The maximum exposure is defined as the average exposure plus three standard deviations. This means statistically, 99.9 percent of plant exposures are less than this maximum.
4. Ignoring the presence of 235 U and using 1 uCi as the ALI for Uranium while ignoring the presence of all other transuranics except for 237 Np, and using 0.004 uCi as the ALI for the transuranics is a conservative approach.

$$\begin{aligned}\text{Average Inhalation dose} &= [7.65\text{E-}15 \times 2000 \times 1.2 \times 1\text{E}6 \times 1/1.004 + 4.4\text{E-}14 \times 2000 \times 1.2 \times 1\text{E}6 \times 1/1] \times 5000 \\ &= [0.00459 + 0.000105] \times 5000 \\ &= 23 \text{ mRem}\end{aligned}$$

$$\begin{aligned}\text{Maximum Inhalation Dose} &= [4.06\text{E-}14 \times 2000 \times 1.2 \times 1\text{E}6 \times 1/1.004 + 3.44\text{E-}13 \times 2000 \times 1.2 \times 1\text{E}6 \times 1/1] \\ &= [.02436 + 0.0008256] \times 5000 \\ &= 126 \text{ mRem}\end{aligned}$$

EXPOSURE TO TRANSURANICS BY INGESTION

The basic formula for the computation of ingestion dose resulting from exposure to transuranics at PGDP is shown below.

Ingestion dose = [quantity of transuranics ingested per day (uCi/day) X days exposure (days)/ALI-TRU + quantity of Uranium ingested per day (uCi/day) X days exposed (days)/ALI-U] X 5000

Transuranics at PGDP are assumed to be class W and uranium, class D. The ingestion ALIs for the radioisotopes found at PGDP are shown below.

Radioisotope	Annual Limit of Intake
235 U	10.0 uCi
238 U	10.0 uCi
237 Np	0.5 uCi
238/238 Pu	0.8-0.9 uCi
230 Th	4.0 uCi

Assumptions made in completing the calculations are as follows.

1. On the average, an industrial worker ingests about 100 mg of dirt from his hands. This is about the quantity of material found on 100 square centimeters of a reasonably clean plant.
2. A maximally exposed worker will be at work approximately 233 days (250 working days per year less 12 national holidays and 5 days miscellaneous absences).
3. Ignoring the presence of 235 U does not introduce any error in the estimate. Using the ALI for 237 Np as the ALI for all the transuranics in the mixture is conservative.

$$\begin{aligned} \text{Average Ingestion dose} &= [54 \cdot 233 / (2.2 \text{E}6 \cdot 0.5) + 649 \cdot 233 / (2.2 \text{E}6 \cdot 10)] \cdot 5000 \\ &= [0.0114 + .00687] \cdot 5000 \\ &= 91 \text{ mRem} \end{aligned}$$

$$\begin{aligned} \text{Maximum Ingestion Dose} &= [528 \cdot 233 / (2.2 \text{E}6 \cdot 0.5) + 6748 \cdot 233 / (2.2 \text{E}6 \cdot 10)] \cdot 5000 \\ &= [0.1101 + .0714] \cdot 5000 \\ &= 907 \text{ mRem} \end{aligned}$$